PATENT APPLICATION TRANSMITTAL LETTER
(Small Entity)

Docket No.
80204-1302

jc525 U.S. PTO
09/412440
10/05/99

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Transmitted herewith for filing under 35 U.S.C. 111 and 37 C.F.R. 1.53 is the patent application of:

David E. Vokey, Kenneth N. Sontag and Myron Loewen

For: **A CONSTANT CURRENT TERMINATION FOR CABLE LOCATING TONES**

10/05/99 jc525 U.S. PTO

Enclosed are:

- ☐ Certificate of Mailing with Express Mail Mailing Label No.
- ☒ **2** sheets of drawings.
- ☐ A certified copy of a application.
- ☒ Declaration ☒ Signed. ☐ Unsigned.
- ☒ Power of Attorney
- ☐ Information Disclosure Statement
- ☐ Preliminary Amendment
- ☒ **Small Business** Verified Statement(s) to Establish Small Entity Status Under 37 C.F.R. 1.9 and 1.27.
- ☒ Other: **Assignment, Assignment Cover Sheet**

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	20	- 20 =	0	x $9.00	$0.00
Indep. Claims	4	- 3 =	1	x $39.00	$39.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
				BASIC FEE	$380.00
				TOTAL FILING FEE	$419.00

- ☒ A check in the amount of **$380.00** to cover the filing fee is enclosed.
- ☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **01-0310** as described below. A duplicate copy of this sheet is enclosed.
  - ☒ Charge the amount of **$39.00** as filing fee.
  - ☒ Credit any overpayment.
  - ☒ Charge any additional filing fees required under 37 C.F.R. 1.16 and 1.17.
  - ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Dated: **October 4, 1999**

Signature

MURRAY E. THRIFT
Registration 27,527

cc:

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) AND 1.27 (c)) - SMALL BUSINESS CONCERN	Docket No. 80204-1302

Serial No.	Filing Date	Patent No.	Issue Date

Applicant/
Patentee: **David E. Vokey; Kenneth N. Sontag; Myron Loewen**

Invention: **A Constant Current Termination for Cable Locating Tones**

I hereby declare that I am:

- ☐ the owner of the small business concern identified below:
- ☑ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: **Norscan Inc.**
ADDRESS OF CONCERN: **7 Terracon Place, Winnipeg Manitoba Canada R2J 4B3**

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the above identified invention described in:

- ☒ the specification filed herewith with title as listed above.
- ☐ the application identified above.
- ☐ the patent identified above.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed on the next page and no rights to the invention are held by any person, other than the inventor, who could not qualify as an independent inventor under 37 CFR 1.9(c) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

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Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☒ no such person, concern or organization exists.
- ☐ each such person, concern or organization is listed below.

FULL NAME _____
ADDRESS _____

☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME _____
ADDRESS _____

☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME _____
ADDRESS _____

☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

FULL NAME _____
ADDRESS _____

☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING: KENNETH N. SONTAG

TITLE OF PERSON SIGNING OTHER THAN OWNER: PRESIDENT

ADDRESS OF PERSON SIGNING:

SIGNATURE: _____ DATE: SEPT. 15/99

A CONSTANT CURRENT TERMINATION FOR CABLE LOCATING TONES

FIELD OF THE INVENTION

The present invention relates to the field of cable location and more particularly to the location of hidden or underground cables using a tone signal applied to the cable.

BACKGROUND

Telephone, cable television and other communication and control cables are often buried or placed in underground duct structures. For this type of cable placement, the most significant cause of cable outages is from dig ups by contractors. In an effort to minimize inadvertent dig ups, "call before you dig" programs are heavily promoted. The operating company must then be able to quickly and accurately locate and mark the buried cable.

Methods have been developed and are in commercial use which place in a locating tone on the cable armour or shield. A special receiver with magnetic field detecting coils is used to sense the tone current travelling along the cable. The strength of the received signal is directly proportional to the magnitude of the tone current in the cable sheath directly below the receiver.

The transmission circuit for the tone signals is formed by the metal armour or shield and insulated by the plastic cable jacket from earth which forms the return conductor. The circuit is basically a coaxial transmission path with the insulated cable armour forming the inner conductor and the surrounding earth forming the outer conductor.

The tone current must be present on all segments of a cable at a level greater than the minimum current dictated by the receiver sensitivity. This requires a termination at the end of the cable to draw at least the minimum amount of current. A

distribution cable typically has a number of branch cables which must also draw enough tone current for cable locating. Since the tone is heavily attenuated by the cable, the terminations near the source will load a much higher signal level than the distant terminations. To compensate for this, most installations use terminators with different signal load impedances for near, middle and far terminations. In addition to the inconvenience of using plural different impedance, the known systems require recalculation and replacement of the terminators when an additional branch is connected.

Where a cable is damaged, the tone signal level may fall below the minimum, making it difficult or impossible to locate the damaged cable.

SUMMARY

The present invention simplifies the terminator selection and mitigates problems created by the addition of branches and by cable damage.

According to one aspect of the present invention there is provided a constant current termination for cable locating tones, comprising:

a first terminal for connection to a tone conductor of a cable to be terminated;

a second terminal to be connected to a tone signal return path;

a load impedance connected between the first and second terminals; and

an active component responsive to variations in a voltage between the first and second terminals to vary the magnitude of the load impedance to maintain a substantially constant current through the load impedance.

According to another aspect of the present invention there is provided a tone locating system for a cable installation having a backbone cable, a plurality of branch cables, splices coupling the branch cables to the backbone cable and tone

conductors along the backbone and branch cables, the tone conductors being connected at the splices, the locating system comprising:

a tone source connected to the tone conductor of the backbone cable at an inner end of the backbone cable;

a plurality of terminations connected to the respective tone conductors at ends thereof remote from the tone source and the splices, each termination comprising:

a load impedance connected to the respective tone conductor and to a tone signal return path; and

an active component responsive to variations in a voltage between the respective tone conductor and the return path to vary the magnitude of the load impedance to maintain a substantially constant current through the load impedance.

The invention thus simplifies the terminator selection and installation by replacing all of the different fixed load terminators of the prior art with a single device. A termination according to the invention draws only enough tone current to ensure location of the cable. It is not affected by the signal strength. This has the additional benefit of allowing the location of a damaged cable when the tone signal level is below that for which a fixed terminator would have been designed. If branches are added later, the termination loads do not have to be recalculated and replaced as with fixed terminators.

In a preferred embodiment of the present invention, the termination circuit has an input terminal for connection to the tone conductor of the cable and an output terminal for connection to a ground return path. A lighting protection device, e.g. a gas tube surge suppresser, a MOV or both, bridges the two terminals. A I high pass filter is connected in series with the lighting protection to block low frequencies

used by either equipment on the same cable conductor. Also in series with the lighting protection and the high pass filter is a band stop filter for filtering induced mains frequency signals. The signal thus processed is delivered to a rectifier, the output of which is connected to a series circuit including the load resistor and a variable impedance, which is in the preferred embodiment the drain to source path of a field effect transistor (FET). The gate and source of the FET are connected across the load resistor. The FET regulates the gate - source voltage and therefore the current draw of the load resistor. A high frequency bypass filter bridges the source and drain terminals of the FET to prevent ringing since the FET may turn on and off very quickly around the current limit with very large input tones. A zener diode is connected in parallel with the load resistance to prevent damage to the FET from input surges.

Other embodiments of the invention are possible using other forms of current limiting circuit, for example a voltage regulator based circuit.

According to a further aspect of the invention there is provided a method of providing a controlled signal current on a cable having opposite inner and outer ends and a signal conductor along a cable between the inner and outer ends, said method comprising:

applying an electrical signal to the signal conductor adjacent the inner end of the cable;

providing a resistive termination at the outer end of the cable, connecting the signal conductor to a signal return path;

monitoring the electrical signal at the termination; and

maintaining a substantially constant electrical signal current at the termination by varying the resistive termination in response to variations in the electrical signal at the termination.

20. According to another aspect of the invention there is provided a method of providing a controlled signal current on each of a backbone cable with inner and outer ends and a signal conductor from the inner end to the outer end and a plurality of branch cables with respective inner and outer ends and with the inner ends spliced to the backbone cable, each of the branch cables having a signal conductor spliced at the inner end of the branch cable to the signal conductor of the backbone cable, the method comprising:

applying an electrical signal to the signal conductor at the inner end of the backbone cable;

providing resistive terminations at the outer end of the backbone cable and at the outer end of each branch cable, connecting the signal conductor to a signal return path;

monitoring the electrical signal at each termination; and

maintaining a substantially constant electrical signal current at each termination by varying the resistive termination in response to variations in the electrical signal at the termination.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings, which illustrate an exemplary embodiment of the present invention:

Figure 1 is a representation of an exemplary cable topology showing termination and ground leakage currents;

Figure 2 is a graph showing voltage and current draw waveforms;

Figure 3 is a circuit schematic of a termination according the present invention.

DETAILED DESCRIPTION

Referring to the accompanying drawings Figure 1 illustrate a cable

system 10 that includes a backbone cable 12 and branch cables 14. Each of these cables has a core 16, a metallic armour 18 surrounding the core and a plastic material outer jacket 20. The branch cables 14 are connected to the backbone cable and splices 22. In the illustrated embodiment, the armour 18 of the cables is connected at the splices to serve as electrically connected tone conductors.

At an inner end of the backbone cable is a tone source 24 that applies a tone signal to the tone conductor. This is transmitted down the conductor to a termination 26 at the outer end of each of the cables.

The transmitter 24 generates a tone on the cable system including the backbone cable 12 and the branch cables 14. The terminations, cable faults and cable capacitance to ground load down the signal. Loading of the signal is important because the current that flows generates a magnetic field around the cable. This radiated field is not blocked by the surrounding soil and is readily detectable several metres away. The locating receiver has a coil that is excited by the magnetic field and converts the field back into an electrical signal.

Signals other than the locate tone may be induced on the cable, from low frequency power line harmonics to broadcast radio frequency signals. The noise level, sensitivity of the receiver and the maximum buried depth of the cable set the minimum required tone current. The Biot-Savart law establishes the relationship of the magnetic field intensity (H), tone current (I) and cable depth (r). The factor a_0 is a constant. This equation is simplified for DC current, but the relationship is the same.

$$H = \frac{I}{2\pi r} a_0$$

In normal practice, the minimum locating current specified by the receiver sensitivity for cable depth of one to two metres is 5 ma. This assumes typical ground conditions and noise levels. For extra safety margin, the minimum locating

current on each segment should be 10 ma. Thus in Figure 1, currents i_1, i_2, i_3, i_4 and i_5 should be 10 ma. Some current, designated i_6, i_7 and i_8 in Figure 1 will be drawn by the cables' capacitive coupling to ground, especially with the higher frequency tones. Since the branches off the main cable may be very short and not have much capacitance, this current cannot be relied upon for locating all segments. When designing the tone source, this current has to be added to the maximum permissible fault current plus the number of terminations times the minimum locating current. The termination must draw the minimum locating current to ensure that no segment between the source and termination will carry less than the minimum current. In the example illustrated in Figure 1, the tone source must supply current equal to $i_1 + i_6$. Current i_1 is in turn the summation of the remaining currents i_2 through i_5 as shown in the drawing.

The load of each of the terminations 26 must draw the minimum required location current regardless of the input voltage or tone frequency. The electrical schematic of each termination is illustrated in Figure 3. As shown in that drawing the termination has input terminals 28 and 30. Terminal 28 connects to the tone conductor of the cable while terminal 32 is connected to a ground return path. A lighting protection surge suppressor 32 is connected to the incoming signal wires to protect the termination from lightning.

The output terminal of the surge suppressor leads to a high pass filter 34 in the form of a large capacitor C1. Other equipment in the cable system may be connected to the cable sheath. This equipment generally operates at very low frequencies, much below the locating tones. The high pass filter 32 prevents interference with the other functions of the tone conductor so that when the locate tone is not applied, the termination will not load down the cable.

In series with the surge suppressor 32 and the high pass filter 34 is a

band stop filter 36. The tone conductor typically has induced AC voltages from power lines at significant levels relative to the locate tone. These induced voltages are also loaded by the termination and add to the drawn current. If the voltages are large enough, they cause the current to limit at the minimum locating current. If a tone signal arrives at the termination with the current already limited, there will be no current draw at the tone frequency. If current is not drawn at the correct frequency, the locating receiver will filter away the signal from the current that is drawn and will not be able to find the cable. The band stop filter 36 includes an inductor L1 and a capacitor C2 connected in parallel. The inductance and capacitance are calculated as follows:

$$freq = \frac{1}{2\pi\sqrt{LC}}$$

At the design frequency, normally 60hz or 50hz depending on the local mains frequency, the impedance of the inductor is equal and opposite to that of the capacitor. The currents are 180° out of phase and cancel each other out. For lower frequencies, the inductor shorts out the capacitor and for higher frequencies the inductor shorts out the inductor.

In series with the surge suppresser 34, high pass filter 34 and band stop filter 36 is a rectifier 38. This is a diode bridge composed of four diodes D1 to provide a full wave rectification of the AC tone signal applied to the terminals 28 and 30. The output of the rectifier 38 is connected to a series circuit including a load impedance 40 and an active component 42. The load impedance 40 is a resistor R1, while the active component is a field effect transistor Q1 with the gate and source terminals connected across the resistor R1 and its drain terminal connected to the rectifier 38. The full wave rectifier 38 is employed in this embodiment because the constant current regulator is a DC device and the incoming tones are AC.

The constant current regulator works by detecting the current through the load resistor R1 and limiting the current when it reaches a set threshold. It limits the current by increasing the series impedance of the circuit so that the load resistor R1 gets less current. The impedance in this case is controlled by the biasing the depletion mode FET Q1 so that its gate voltage decreases relative to the source voltage as the drawn current increases. This will limit the gate voltage to the gate threshold voltage because any more current would gradually turn off the transistor.

$$I_{\mathrm{lm}\,it} = \frac{V_{gs}}{R_{sense}}$$

Since the gate voltage is limited and the load resister is fixed, the drawn current I_{limit} is limited to:

The voltage V_{gs} is a specification of the depletion mode FET, so R1 is chosen to set I_{limit} to the minimum locate current.

The resulting current wave form is shown in Figure 2. It will look like the tone signal with the peaks chopped off because the current increases with the input tone voltage until the set current limit. The current stays at the limit until the tone input voltage comes back down. With a strong tone signal near the beginning of the cable, the current waveform will approach that of a sign wave. A square wave of current is acceptable because the tone receiver locating the cable will filter harmonics and only detect the fundamental frequency.

The fourier expansion for a square wave is given by:

$$f(x) = \frac{4}{\pi}\sum_{n=1,3,5\ldots}\frac{1}{n}\sin\frac{n\pi x}{L} = \frac{4}{\pi}\sin\frac{\pi x}{L} + \frac{4}{\pi}\sum_{n=3,5,7\ldots}\frac{1}{n}\sin\frac{n\pi x}{L}$$

This indicates that the peak amplitude of the first harmonic (n=1) will be $4/\pi$ times greater than the square wave peak. The peak of the sign wave must then be converted to an RMS value as follows:

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}} = \frac{4/\pi}{\sqrt{2}} = 0.900$$

With the tone current being 0.900 of the current limit, the calculations for the current limit will have to be 1/.9 or 11% higher than the minimum desired locate current.

In use of the termination illustrated in Figure 3, the lightning protector 32 protects the circuit from lightning. The capacitor C1 blocks DC and passes AC signals including the tone signal. The band stop filter 36 blocks any induced mains frequency currents. The rectifier 38 rectifies the incoming signal because the following current regulator is limited to one polarity. The field effect transistor Q1 regulates the gate to source voltage across the load resistor R1 to about 1.77 volts. The minimum locate current of 10 ma results in a maximum current limit set to 11.1 ma from the 11% correction calculated above. The value for the load resistor R1 is calculated as the gate to source voltage divided by the current limit. The high frequency bypass capacitor C3 prevents ringing as the FET would turn on and off very quickly around the current limit with very large input tones. The zener diode D2 clamps the gate voltage to a tolerable limit, say 5 volts, to prevent damage to FET Q1.

With this circuit tolerances may be quite large for the inductor L1 and some tuning of the capacitor C2 may be required to centre the band filter at 60 Hz or 50 Hz as the case may be.

While one embodiment of the present invention has been described in the foregoing, it is to be understood that other embodiments are possible within the scope of the invention. For example, various different forms of constant current regulator may be employed. It is for example, possible to produce a regulator for both polarities, thus eliminating the rectifier. Voltage regulator based limiters, can for example, be used. The invention is therefore to be considered limited solely by the

scope of the appended claims.

CLAIMS

1. A constant current termination for cable locating tones, comprising:

a first terminal for connection to a tone conductor of a cable to be terminated;

a second terminal to be connected to a tone signal return path;

a load impedance connected between the first and second terminals; and

an active component responsive to variations in a voltage between the first and second terminals to vary the magnitude of the load impedance to maintain a substantially constant current through the load impedance.

2. A termination according to Claim 1 wherein the load impedance is a resistance.

3. A termination according to Claim 2 including a rectifier with an input for the cable locating tones and a rectified output, the load impedance being connected across the rectified output.

4. A termination according to Claim 3 wherein the active component comprises a field effect transistor with gate, drain and source terminals, the gate and drain terminals being connected across the output of the rectifier and the gate and source terminals being connected across a load resistor.

5. A termination according to Claim 4 including a high pass filter connected across the drain and source terminals.

6. A termination according to Claim 5 including a voltage limiter connected across the gate and source terminals for limiting the voltage at the gate terminal.

7. A termination according to Claim 3 including a mains frequency blocking filter connected to the rectifier input.

8. A termination according to Claim 7 including a high pass filter connected

to the mains frequency blocking filter.

9. A termination according to Claim 3 including a surge suppressor connected between the first and second terminals.

10. A tone locating system for a cable installation having a backbone cable, a plurality of branch cables, splices coupling the branch cables to the backbone cable and tone conductors along the backbone and branch cables, the tone conductors being connected at the splices, the locating system comprising:

a tone source connected to the tone conductor of the backbone cable at an inner end of the backbone cable;

a plurality of terminations connected to the respective tone conductors at ends thereof remote from the tone source and the splices, each termination comprising:

a load impedance connected to the respective tone conductor and to a tone signal return path; and

an active component responsive to variations in a voltage between the respective tone conductor and the return path to vary the magnitude of the load impedance to maintain a substantially constant current through the load impedance.

11. A system according to Claim 10 wherein the load impedance includes a load resistor and the active component comprises means for maintaining the voltage across the load resistor substantially constant.

12. A system according to Claim 11 wherein the active component is a field effect transducer.

13. A system according to Claim 11 including a rectifier with an input connected between the tone conductor and the return path and an output connected to a series circuit including the load resistor and the source and drain terminals of the

field effect transducer.

14. A system according to Claim 13 including a high frequency pass filter connected in parallel with the drain and source terminals of the field effect transistor.

15. A system according to Claim 14 including a voltage limiting component connected across the gate and source terminals of the field effect transistor.

16. A system according to Claim 13 including a mains frequency blocking filter connected to the rectifier input.

17. A system according to Claim 16 including a high pass filter connected to the mains frequency blocking filter.

18. A system according to Claim 10 including a surge suppresser connected between the tone conductor and the tone signal return path.

19. A method of providing a controlled signal current on a cable having opposite inner and outer ends and a signal conductor along a cable between the inner and outer ends, said method comprising:

applying an electrical signal to the signal conductor adjacent the inner end of the cable;

providing a resistive termination at the outer end of the cable, connecting the signal conductor to a signal return path;

monitoring the electrical signal at the termination; and

maintaining a substantially constant electrical signal current at the termination by varying the resistive termination in response to variations in the electrical signal at the termination.

20. A method of providing a controlled signal current on each of a backbone cable with inner and outer ends and a signal conductor from the inner end to the outer end and a plurality of branch cables with respective inner and outer ends and with the inner ends spliced to the backbone cable, each of the branch cables having a signal

conductor spliced at the inner end of the branch cable to the signal conductor of the backbone cable, the method comprising:

applying an electrical signal to the signal conductor at the inner end of the backbone cable;

providing resistive terminations at the outer end of the backbone cable and at the outer end of each branch cable, connecting the signal conductor to a signal return path;

monitoring the electrical signal at each termination; and

maintaining a substantially constant electrical signal current at each termination by varying the resistive termination in response to variations in the electrical signal at the termination.

ABSTRACT

A constant current termination is provided for cable locating tones on communication and control cables that may be buried or placed in underground duct structures. The constant current termination limits the current on each branch of the cable to that required for cable location, thus ensuring that branches furthest from the tone source have adequate current for location purposes. The termination is the same for each branch, regardless of its position along the cable system. This eliminates the need to calibrate and recalibrate termination distances for a cable on installation and when branches are added. It also allows the location of damaged cables where the tone signal strength on a damaged brat is less than that for which the termination was designed.

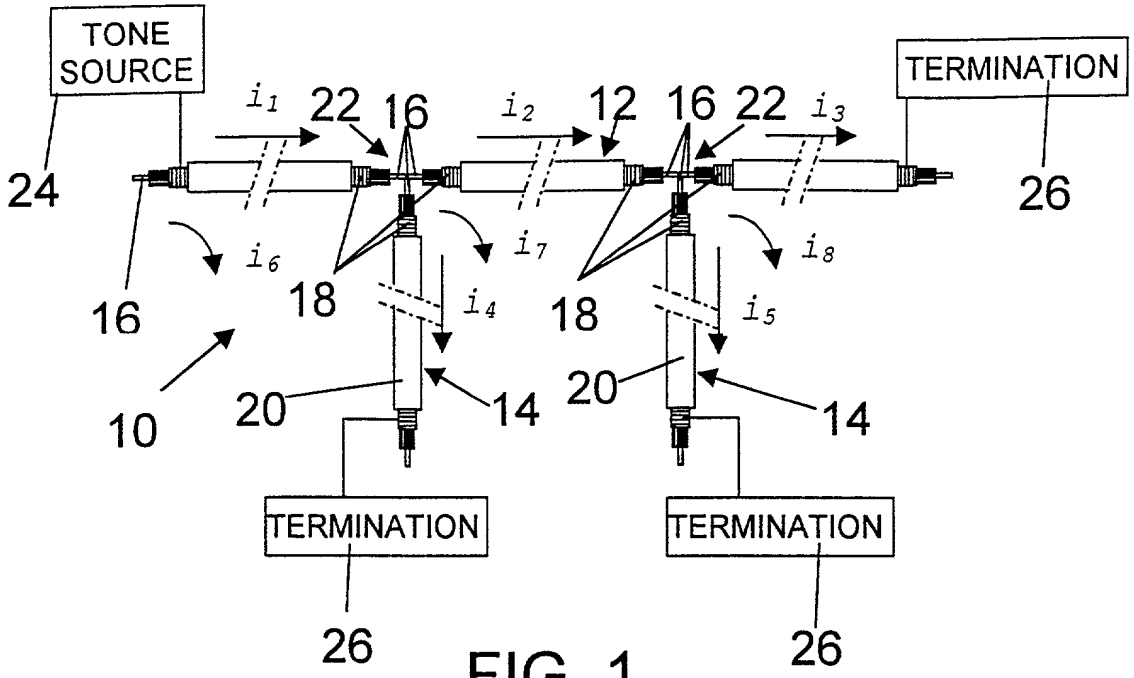

TONE SOURCE
TERMINATION
24
26
i_1
22
16
i_2
12
16
22
i_3
i_6
i_7
i_8
16
18
i_4
18
i_5
10
20
14
20
14
TERMINATION
TERMINATION
26
26

FIG. 1

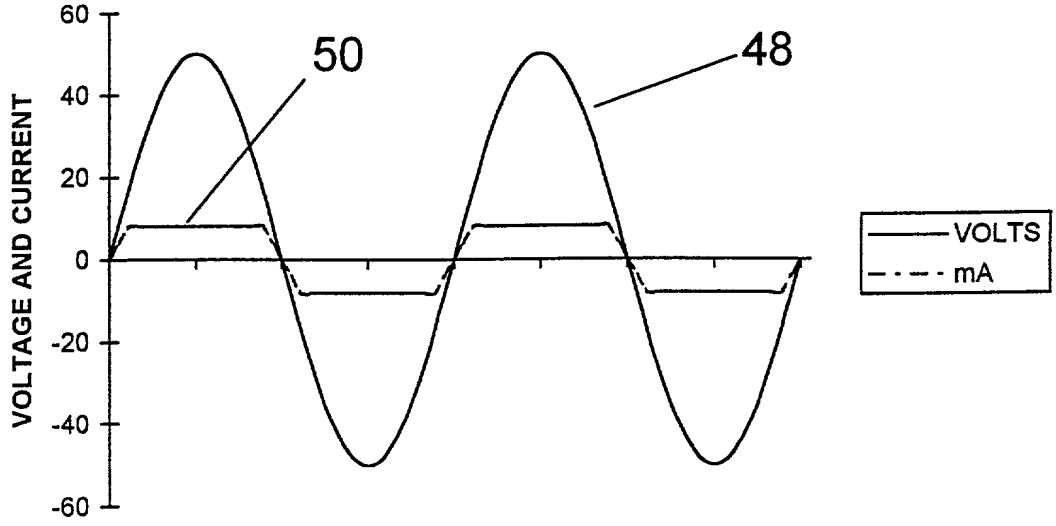

60
40
20
0
-20
-40
-60
VOLTAGE AND CURRENT
50
48
VOLTS
mA

FIG.2

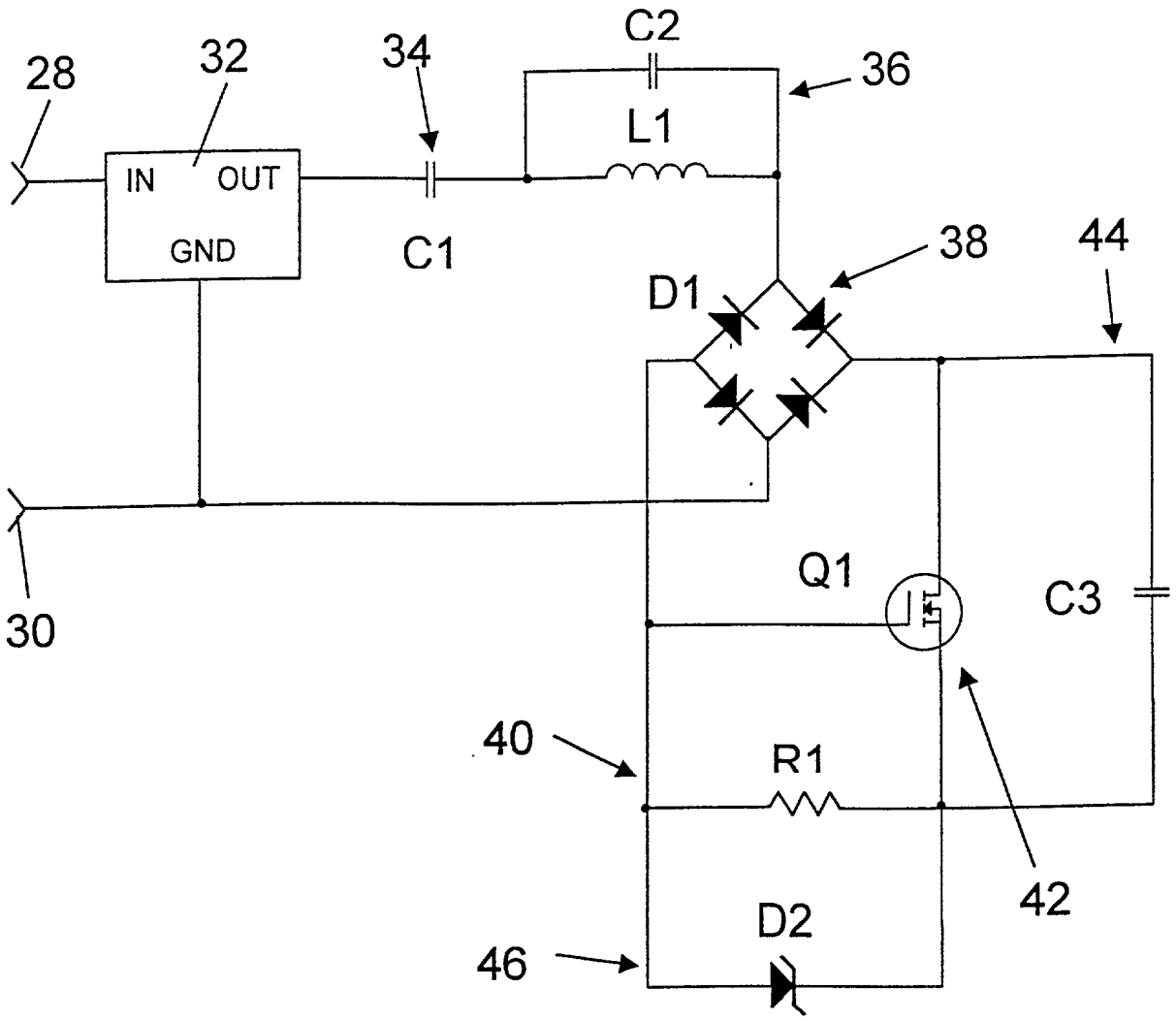


FIG. 3

Docket No.
80204-1302

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

A Constant Current Termination For Cable Locating Tones

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____

and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐
(Number)	(Country)	(Day/Month/Year Filed)	☐

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

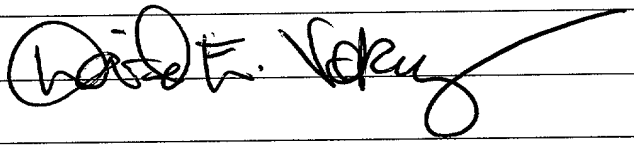
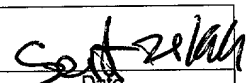
I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

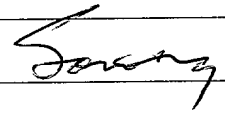
POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

Murray E. Thrift 27,527
Adrian D. Battison 31,726

Send Correspondence to: **ADE & COMPANY**
1700-360 Main Street
Winnipeg Manitoba
Canada R3C 3Z3

Direct Telephone Calls to: *(name and telephone number)*
Murray E. Thrift

Full name of sole or first inventor **David E. Vokey**
Sole or first inventor's signature  Date 
Residence **Bellingham Washington USA**
Citizenship
Post Office Address **1206 Northwind Circle, Bellingham, Washington USA 98226**

Full name of second inventor, if any **Kenneth N. Sontag**
Second inventor's signature  Date Sept. 15/99
Residence **Manitoba Canada**
Citizenship **Canadian**
Post Office Address **Box 21, Group 429, R.R. #5, Winnipeg Manitoba Canada R2C 2Z2**

Full name of third inventor, if any
Myron Loewen

Third inventor's signature

Date
Sept 13/99

Residence
Manitoba Canada

Citizenship
Canadian

Post Office Address
Box 933, Niverville, Manitoba Canada R0A 1S0

Full name of fourth inventor, if any

Fourth inventor's signature

Date

Residence

Citizenship

Post Office Address

Full name of fifth inventor, if any

Fifth inventor's signature

Date

Residence

Citizenship

Post Office Address

Full name of sixth inventor, if any

Sixth inventor's signature

Date

Residence

Citizenship

Post Office Address

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